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THE USE OF SUBSTITUTE FUELS IN AXIS EUROPE, 1943

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THE USE OF SUBSTITUTE FUELS IN AXIS EUROPE, 1943

SUMMARY

The year 1943 has witnessed a large expansion in the use of substitute fuelled motors, especially in Germany. Up to the beginning of 1942, the development in the Reich lagged far behind that of France and of other countries of Western and Northern Europe. As long as Germany maintained reasonable hopes for the conquest of large oil fields in the Caucasus, the use of cumbersome generator motors was not pushed energetically. Occupied countries, where allocations of liquid fuels had long been reduced to a bare minimum, had advanced much further in their use. However, since the autumn of 1942 Germany has bent all efforts on converting road vehicles and motors used in agriculture, inland shipping, industry and railways to the use of solid and gaseous fuels.

By July 1943, there were in Axis Europe some 410,000 substitute fuelled vehicles, ~~nearly~~ more than five-sixths of which were trucks. About four-fifths of the total number of converted road vehicles used solid fuels and one-fifth gaseous fuels. Nearly one-third of the total number of substitute fuelled units were stationed in Germany and another third in France. The remaining vehicles were divided between all the other countries of Axis Europe (see Tables I to III).

The quantities of liquid fuels saved by the use of gaseous and solid substitute fuels has been estimated at 1,300,000 tons, or about one-fifth of the total quantity of all liquid fuels and lubricants allocated to industrial and civilian uses in 1943. Savings in the various countries were mainly dependent on the number of substitute fuelled motors but also to a considerable extent on the quantities of substitute

fuels which could be made available. Nearly half of the total savings were achieved in Germany and only about one-sixth in France.

Road transportation accounted for about three-fourths of the total consumption of substitute fuels outside of Occupied Russia; substitute fuels represented slightly more than two-fifths of all liquid and substitute fuels required by road vehicles. Substitutes also satisfied about one-sixth of total agricultural fuel requirements, while the corresponding proportion in shipping and industry remained well below one-tenth.

Further progress in substitution can be expected in 1944, especially in Germany and Eastern Europe. In the autumn of 1943, it was announced that a light type of generator had been developed, suitable for the conversion of small trucks and private cars, which were still using liquid fuels. The use of substitute fuels in Eastern Europe, especially in the Balkans, where the development has been lagging most seriously, will be pushed more vigorously. Available quantities of substitute fuels are limited, however, and the establishment and maintenance of an efficient distribution system presents additional problems. The supply of raw material and skilled labor for the manufacture and utilization of generator motors offers further difficulties. The manifold technical disadvantages of a generator motor impose limitations on its use. For these reasons, total additional savings by use of substitute fuels in 1944 probably will not exceed, and may fall below, 300,000 tons.

The appended Tables I to III contain estimates of the number of motor vehicles converted to gaseous and solid substitutes as of July 1943, of the quantities of liquid fuels saved by their use, and of the

quantities of liquid fuels and lubricants consumed by substitute driven vehicles. These figures have been built up from estimates, by use and country, of the number of substitute fuelled motors and the quantities of liquid fuels replaced. The considerations governing the individual basic estimates are presented in the following pages.

TABLE I

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NUMBER OF GASEOUS AND SOLID SUBSTITUTE FUEL USING MOTOR VEHICLES IN AXIS EUROPE AS OF JULY 1943[1]

(Thousand Units)

AXIS AND AXIS SATELLITES	Private Cars			Buses			Trucks			Total Road Vehicles		
	Using			Using			Using			Using		
	Solid Fuels	Gaseous Fuels	Total	Solid Fuels	Gaseous Fuels	Total	Solid Fuels	Gaseous Fuels	Total	Solid Fuels	Gaseous Fuels	Grand Total
Germany	8.0	2.0	10.0	2.0	1.0	3.0	105.0	12.0	117.0	115.0	15.0	130.0
Protectorate and Slovakia	.3	.2	.5	.2	.3	.5	6.0	--	6.0	6.5	.5	7.0
Italy	2.5	6.5	9.0	1.5	1.5	3.0	11.0	17.0	28.0	15.0	25.0	40.0
Hungary	.2	.3	.5	--	--	--	.5	.5	1.0	.7	.8	1.5
Bulgaria	.2	.1	.3	.5	--	.5	1.2	--	1.2	1.9	.1	2.0
Finland	2.5	--	2.5	1.0	--	1.0	6.0	--	6.0	9.5	--	9.5
OCCUPIED COUNTRIES OF WESTERN AND NORTHERN EUROPE												
France	2.0	2.0	4.0	1.0	2.0	3.0	97.0	18.0	115.0	100.0	22.0	122.0
Belgium	.5	2.3	2.8	.5	.3	.8	9.0	7.5	16.5	10.0	10.1	20.1
Holland	.5	.5	1.0	.3	.5	.8	16.0	.2	16.2	16.8	1.2	18.0
Denmark	2.0	.5	2.5	.5	.2	.7	17.0	.5	17.5	19.5	1.2	20.7
Norway	3.0	--	3.0	1.0	--	1.0	16.0	--	16.0	20.0	--	20.0
OCCUPIED COUNTRIES OF EASTERN AND SOUTHERN EUROPE												
Baltic States	.1	--	.1	.1	--	.1	2.0	--	2.0	2.2	--	2.2
General Government of Poland	.2	.2	.4	.3	.2	.5	2.0	1.0	3.0	2.5	1.4	3.9
Occupied Russia	1.0	--	1.0	1.0	--	1.0	10.0	--	10.0	12.0	--	12.0
Serbia and Croatia	.1	.1	.2	.1	.1	.2	.6	.3	.9	.8	.5	1.3
Greece	.1	--	.1	.2	--	.2	.4	--	.4	.7	--	.7
TOTAL	23.2	14.7	37.9	10.2	6.1	16.3	299.7	57.0	356.7	333.1	77.8	410.9

1 Excluding military vehicles.

TABLE II

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QUANTITIES OF LIQUID FUELS SAVED BY THE USE OF GASEOUS AND SOLID SUBSTITUTE FUELS IN AXIS EUROPE[1], 1943

(Thousand metric tons)

AXIS AND AXIS SATELLITES	Road Transport		Railways		Shipping	Agriculture		Industry		Total		
	Light Motor Fuel	Gas Oil	Light Motor Fuel	Gas Oil	Gas Oil	Light Motor Fuel	Gas Oil	Light Motor Fuel	Gas Oil	Light Motor Fuel	Gas Oil	Grand Total
Germany	432.0	71.0	---	14.0	15.0	55.0	27.0	1.0	10.0	488.0	137.0	625.0
Protectorate and Slovakia	26.3	2.4	2.0	.6	.6	4.0	.6	2.0	---	34.3	4.2	38.5
Italy	49.0	10.0	2.0	1.0	---	5.0	2.0	1.0	---	57.0	13.0	70.0
Hungary	3.5	1.0	---	---	---	---	---	---	---	3.5	1.0	4.5
Bulgaria	8.2	---	---	---	---	---	---	---	---	8.2	---	8.2
Finland	25.0	1.2	---	---	---	6.0	---	2.0	1.0	33.0	2.2	35.2
OCCUPIED COUNTRIES OF WESTERN AND NORTHERN EUROPE												
France	152.0	40.0	6.0	1.0	1.0	6.0	--	12.0	---	176.0	42.0	218.0
Belgium	36.0	4.0	2.0	---	1.0	2.0	--	---	---	40.0	5.0	45.0
Holland	40.0	1.0	2.0	1.0	3.0	2.0	--	---	---	44.0	5.0	49.0
Denmark	42.0	---	---	1.0	1.0	2.0	--	---	4.0	44.0	6.0	50.0
Norway	42.0	---	---	---	2.0	2.0	--	1.0	3.0	45.0	5.0	50.0
OCCUPIED COUNTRIES OF EASTERN AND SOUTHERN EUROPE												
Baltic States	4.1	0.6	---	---	---	2.0	.6	---	---	6.1	1.2	7.3
General Government of Poland	15.2	---	.8	---	---	4.0	---	---	---	20.0	---	20.0
Occupied Russia	33.5	---	---	---	5.0	40.0	---	---	---	73.5	5.0	78.5
Serbia and Croatia	1.6	1.6	---	---	---	1.0	---	---	---	2.6	1.6	4.2
Greece	2.0	---	---	---	---	---	---	---	---	2.0	---	2.0
TOTAL	912.4	132.8	14.8	18.6	28.6	131.0	30.2	19.0	18.0	1077.2	228.2	1305.4

1 Excluding military vehicles.

TABLE III CONFIDENTIAL

QUANTITIES OF LIQUID FUELS AND LUBRICANTS REQUIRED BY MOTORS CONVERTED TO SUBSTITUTE FUELS[1]

IN AXIS EUROPE, 1943

(Thousand metric tons)

AXIS AND AXIS SATELLITES	Light Motor Fuel	Gas Oil	Lubricants	Total
Germany	23.4	68.5	30.0	121.9
Protectorate and Slovakia	1.5	2.1	1.9	5.5
Italy	2.0	6.5	2.7	11.2
Hungary	.1	.5	.2	.8
Bulgaria	0.4	--	.4	.8
Finland	1.6	1.1	1.8	4.5
OCCUPIED COUNTRIES OF WESTERN AND NORTHERN EUROPE				
France	6.5	21.0	10.3	37.8
Belgium	1.7	2.5	1.7	5.9
Holland	2.5	2.5	2.8	7.8
Denmark	2.4	3.0	2.9	8.3
Norway	2.1	2.5	2.3	6.9
OCCUPIED COUNTRIES OF EASTERN AND SOUTHERN EUROPE				
Baltic States	.3	.6	.4	1.3
General Government of Poland	1.0	--	.9	1.9
Occupied Russia	3.7	2.5	3.9	10.1
Serbia and Croatia	.1	.8	.2	1.1
Greece	.1	--	.1	.2
TOTAL	49.4	114.1	62.5	226.0

1 Excluding military vehicles.

I. QUALITY AND PERFORMANCE OF SOLID AND GASEOUS SUBSTITUTE FUELS

Scope of Study

Substitute fuels considered in the following study comprise all solid and gaseous substitutes, with the exception of liquid gas (propane and butane), which are used to replace liquid fuel in internal combustion engines in road vehicles, ships, locomotives, tractors and stationary machines.

Technical Data on the Different Kinds of Substitutes

The kind of substitute fuels used varies from country to country and district to district. Although in the early stages of the war, wood and charcoal (and anthracite, wherever available) were the main solid substitute fuels, the scarcity of these fuels, coupled with limitations in distribution and transportation, has compelled most countries to develop the use of alternative substitutes such as peat, lignite, and bituminous coal. Information on the efficiency of such fuels and on the quantities needed to replace one kilogram of motor fuel is scanty and contradictory. Moreover, great variations in the quality of even similar kinds of fuels are unavoidable. The following table taken from the German publication "Generator Jahrbuch, 1942" gives some basic technical data for the most common substitutes; the data probably relate to the best quality of each of the various kinds of fuel.

CHARACTERISTICS OF SOLID GENERATOR FUELS[1]

	Wood	Charcoal[2]	Peat	Lignite			Pro-lignite coke[2]	Bit. Coal l.t.c. coke	Anthracite
				Lumps	Briquettes	l.t.c. coke			
Calorific value Cal/kg.	3700	7630	3500	6800	4800	5500	7100	7000	8000
Kg. per cubic m	350	240	300	650	750	630	--	600	800
Energy content per cubic meter (million Cal/m^3)	1.3	1.83	1.05	3.9	3.6	3.5	--	4.2	6.4
Ash content (weight percent)	0.8	----	2.2	up to 10.	up to 10	10-12	--	8-9	4
Sulphur content (weight percent)	---	----	up to 0.15	1.0	0.5-2	1-4	--	0.5-1	0.7-1.5
Water content (weight percent)	25	----	25	4-10	13-16	~10	--	~6	2-3
Gaseous content (weight percent)	---	----	----	7-20	40-45	15-18	--	6-10	~7
Usual size (in millimeters)	50x80	----	25-100	20-50	150 gm	5-20	--	10-18	10-18
1 kg. of gasoline replaced by -- kg. of substitutes	3.5[3]	2.2[4]	3.6	2.5	2.9	2.7	1.9	2.3	1.6

[1] Most data taken from "Generator Jahrbuch, 1942".
[2] Information obtained from other sources.
[3] 1 kg. of diesel oil is replaced by about 4 kg. of wood.
[4] About 4 kg. of wood are needed to produce 1 kg. of charcoal. 1 kg. of gasoline replaced by about 2 kg. of carbide.

For gaseous fuels Dr. Egloff gave the following data in a paper on "Substitute Fuels as a War Economy" presented before the American Chemical Society in April 1942.

HEAT CONTENT OF GASOLINE SUBSTITUTES

1 cubic meter of:	Equivalent to kilogram of gasoline
1. Natural gas	.910
2. Methane	.815
3. City gas	.428

Including the weight of the cylinders the following ratios can be established:

	Cylinder (kg.)	Pressure (atmosphere)	Gas (kg.)	Gasoline Equivalent (kg.)
Methane	52	200-340	13	13
City gas	70	200	6	5

Efficiency of Substitute Driven Vehicles.

The manifold technical problems connected with the use of gaseous and solid substitute fuels will not be discussed in this place. But a few outstanding difficulties may be mentioned. Loss in power of the motor can in general be put at one-fifth to one-quarter. In addition, the pay load of road vehicles is reduced by the size and weight of the generator equipment and fuel. The operation of generator vehicles is considerably more difficult for drivers than the operation of conventional vehicles. Engine life is much reduced and breakdowns are more frequent. More lubricating oil is needed per mile. A completely new distribution system for gaseous and solid substitutes

must be organized, which increases the overall strain on transportation and manpower. Expensive installations have to be built for the compression of gaseous fuels and large quantities of steel are needed for the manufacture of steel bottles. Ignoring all indirect effects on the economy caused by the use of solid and gaseous substitute fuels, the direct loss in the carrying capacity of each converted road vehicle may be put at about one-third.

Although the technical problems encountered in the conversion of carburetor engines to gaseous substitutes and to wood and charcoal have more or less been solved, the use of other substitutes, such as peat and lignite, and the conversion of diesel engines to substitute fuels have not yet been completely mastered.

Because of the loss of power in converted engines it is often necessary to use liquid fuels for quick starting and uphill climbing. For diesel engines, a "diesel cum gas" system has been developed which requires the use of diesel oil, in addition to substitute fuels. Twenty to twenty-five percent of normal requirements of diesel oil are needed for long distance hauls and forty-five percent for city driving.

The following report gives estimates on the number of generators in use in the various Axis European countries. Available intelligence is satisfactory in the case of a few countries only; information on the remaining countries is scanty and contradictory.

Section A

THE USE OF SUBSTITUTE FUELS IN AXIS AND AXIS SATELLITE COUNTRIES, 1943

II. THE USE OF SUBSTITUTE FUELS IN GERMANY DURING 1943

The Number of Civilian Motor Vehicles Using Solid Substitute Fuels

Intelligence on the development and utilization of gaseous and solid substitute fuels in Germany is confusing and contradictory. The only official data available refer to the number of generator vehicles in the middle of 1939 when 1,000 units were in use. American as well as British estimates for war-time developments have been largely based on a speech delivered at the Vienna fair in September 1941 by Schell, the German official who was formerly in charge of the conversion program. A translation of the relevant parts of this speech is presented herewith:

> Since 1941 practically all ~~the~~ new commercial vehicles used in industry have been generator driven. It is also necessary to concentrate all efforts in order to release more liquid fuels for army use by converting agricultural motors, marine engines, stationary engines and construction equipment to substitute fuels.
>
> By the autumn of 1941 there were in use in Germany and the territories controlled by Germany some 150,000 generator vehicles. This conversion allowed a monthly saving of liquid fuel of about 45,000,000 liters (about 400,000 metric tons per annum). In the last quarter of 1941 some 6,000 generator trucks will be produced for use in industry. Of the 16,000 diesel vehicles which are suitable for conversion, three-quarters, that is, 12,000 vehicles, were already earmarked for such conversion at the time when this statistical compilation was made.
>
> Some 6,500 agricultural tractors will also be converted to generator fuel. In addition, it is planned to supply agriculture with 20,000 new generator tractors excluding those which will be sent to the Eastern occupied territories.
>
> At present some 90 generator ships are used in inland shipping. There are 125 ships of 35,000 h.p. which will soon be converted. A total of 1,200 ships is suitable for conversion.
>
> By September 1941, some 80 diesel locomotives and some 130 stationary engines also used generator fuel.
>
> The production of generators for road vehicles will be in-

creased to 33,000 during the last quarter of 1941 and will reach the same level during the first quarter of 1942.

Requirements for generator fuel will amount to an estimated 3 million cubic meters during the year 1941-42 and will be supplied solely by the Generator AG. During 1942-43 requirements will probably increase to 4 million cubic meters. In addition, some 40,000 tons of peat and 100,000 tons of anthracite will be made available this year.

As of September 1941 24 wholesalers and some 700 filling stations distributed generator wood. During the first stage of expansion the number of filling stations will be increased to 780 and during the second phase to 1,500.

The NSKK, which is charged with the instruction of generator drivers, has issued 11,000 driving licenses and 700 teachers' permits up to September 1941. The factories engaged in the conversion of engines to the use of substitute fuels employed in September 1941 about 3,600 men and a labor force of 6,000 men was employed in the production of generators.

On the basis of a careful weighing of all available intelligence, it is now believed that this speech has not been interpreted correctly in American and British studies on the number of generator vehicles in use. Furthermore, the program for the conversion of road vehicles during the last quarter of 1941 and the first quarter of 1942, as presented by Schell, was not actually carried out. Because of the far-reaching consequences of the changes in estimates which will be suggested here, all available evidence will be presented in this report.

According to Schell, by the autumn of 1941 there were some 150,000 generator vehicles in use in Germany and German controlled territories. Reliable evidence is available on the number of generator vehicles at that date in Holland (8,000), Belgium (1,000), Norway (8,000), and Denmark (11,000). The information on the number of generator vehicles in France as of that date is contradictory. Formerly it was estimated that the total amounted to only 60,000 (See Deutsche Bergwerks Zeitung, April 28, 1943). A recent report of the President of the French Comité Général des Carburants de Remplacement states, however, that in

the late summer of 1941 the total amounted to 100,000 units. If that were true, the number of generator vehicles left over for Germany would amount to only 20,000 as compared with a figure of 60,000 which up to now has been used in all British and American reports. The following independent intelligence reports on the number of generator vehicles in Germany confirm the figure of 20,000:

1. Schell in Arbeit und Wehr, quoted in the Frankfurter Zeitung, May 7, 1941, stated:

"At the beginning of the war there were 20,000 motor vehicles driven by liquid gas as compared with 60,000 now; 1,000 vehicles were driven by generator fuel at the beginning of the war, while there are now (1941) 14,000."

2. Professor Foedisch, a high official in the Central Office for Generators, reported in the Verein Deutscher Ingenieure on October 15, 1942:

"As the motor fuel requirements of the Army and Navy increased rapidly after the outbreak of war, it became imperative to make use of solid fuels. The generator has been developed over a long period and the wood gas generator was technically perfect at the beginning of the war. Up to July 1, 1942, 25,000 vehicles have been converted to the use of wood gas. In addition, generators for the use of peat, anthracite, lignite and low-temperature coke have been developed. In July of this year (1942) the Central Office for Generators was charged with the conversion of liquid fuel using motors to solid fuels."

3. The Deutsche Volkswirt in its issue of November 1942 stated:

"The net of filling stations for solid fuels has been expanded. The success of this work is shown by the fact that some 30,000 trucks are driven by substitute fuels."

4. Minister Speer in a speech in June 1943 declared:

"The armament industry was charged to produce and equip all trucks with generators. From June 1, 1942 until today $3\frac{1}{2}$ times as many motor vehicles have been converted to generator fuel as in the three preceding years together. Enormous savings in motor fuel have been achieved equal to the current output of several large plants. This conversion has made it possible to supply increased quantities of motor fuel to the front."

The information contained in the various speeches and articles may be presented in tabular form as follows:

Date of Estimate	Number of Generator Vehicles in Use	Source
September 1939	1,000	Official statistics and article by Schell, May 1941.
April 1941	14,000	Article by Schell, May 1941.
September 1941 (1)	20,000	Present interpretation of speech by Schell of September 1941.
September 1941 (2)	60,000	Former interpretation of speech by Schell of September 1941.
June 1942 (1)	185,000	Based on former interpretation of Schell's September 1941 speech and his indicated program.
June 1942 (2)	25,000	Statement by Foedisch, October 1942.
November 1942	30,000	Article in Deutsche Volkswirt, November 1942.
June 1943 (1)	832,000	Based on Speer's statement of June 1943 and on former interpretation of Schell's September 1941 speech on the number of generator vehicles in use in June 1941, and the progress for future conversions indicated therein.
June 1943 (2)	112,000	Based on Speer's statement (June 1943) and on statement by Foedisch (October 1942), and on articles in Deutsche Volkswirt (November 1942) on the number of generator vehicles in use.

Obviously the figure obtained by combining the data in Schell's speech of September 1941 and that of Speer in June 1943 are absurd; the number of generator vehicles converted by June 1943 would far exceed the total number of all vehicles in use. But even the two estimates by Schell, namely, that of April 1941 and that of September 1941, are irreconcilable if Schell's statement of September 1941 is interpreted to mean that 60,000 generator trucks were converted by that time. This would imply that within 4 months -- from May to September 1941 -- 46,000 vehicles would have been converted to generator fuel. Such a rate of conversion would be higher than the one announced by Schell in September 1941 for his future program. However, Schell's April 1941 statement, that of Foedisch for June 1942, the Deutsche Volkswirt article of November 1942, and Speer's June 1943 speech can be combined into one consistent estimate, leading to a figure of 112,000 vehicles in June 1943. Such interpretation would imply that up to early 1942 the conversion program in Germany had been subject to frequent delays and that progress had been exceedingly slow.

There is overwhelming additional evidence to support this interpretation. The evidence is based on inconsistencies in Schell's speech of September 1941, on overall strategic considerations, and on countless intelligence items, some of which have already been quoted.

The September 1941 statement by Schell is inconsistent. Schell estimated the savings of liquid fuel achieved by the conversion of some 150,000 vehicles -- most of which were trucks -- at only 400,000 tons of liquid fuel per annum or 2.5 tons per vehicle. This compares with an average peacetime rate of consumption of about 4 to 5 tons per truck. Actually, in an article in Oel und Kohle, October 22, 1940,

Schell was quoted as stating that the rate of saving of liquid fuels in Germany, Norway, Denmark, Holland, Belgium and France at that time amounted to 360,000 tons per annum, assuming a monthly consumption of 500 to 600 liters of fuel per vehicle. This would represent an annual consumption of 4.5 tons per unit.

Further, German solid substitute fuel requirements for the year 1941-42 (which most likely refers to the so-called forest year, October 1941-September 1942) were estimated by Schell at 3 million cubic meters of wood, 40,000 tons of peat, and 100,000 tons of anthracite. The optimum liquid fuel equivalent of these solid fuels may be put at 350,000 tons. (See also Oberstleutnant Schanze in Chemische Technik, January 24, 1942). This supply would provide less than 2.4 tons of liquid fuel equivalent per year for each of 150,000 German generator vehicles (the average number of converted German vehicles during the year 1941-42 according to the Schell plan). Nor does this calculation take into account the solid fuel requirements of generators installed in ships, tractors, and agricultural and industrial machines.

Most surprising, however, is the small rate of increase in the solid fuel requirements from 1941-42 to 1942-43, as indicated by Schell. According to his statements the 1942-43 solid fuel requirements would amount to 4 million cubic meters of wood with a liquid fuel equivalent of 400,000 tons. Because of limited supplies an increase in the output of anthracite could obviously not be anticipated and the use of low-temperature coke was not practical at that time. Thus, according to Schell, total savings of liquid fuel in 1942-43 would amount to only 450-500,000 tons. Schell's estimates of fuel require-

ments thus seem to imply that, first of all, the actual savings per converted truck would amount to less than 2.5 tons (in terms of liquid fuel) and, secondly, that a rapid initial expansion in the use of substitute fuels would be followed by a very slow increase. Actually almost the opposite has happened.

This interpretation is further supported by an analysis of the relationship between German oil policy and grand strategy during the period following Schell's September 1941 speech. This was the time of the first great German successes on the Russian front. As long as Germany entertained reasonable hopes that all fighting at the Eastern front would be over in a number of weeks or months, she could expect to balance oil supplies and requirements. As Germany did count on the conquest of large new oil fields in the Caucasus, it is more than likely that she did not wish or feel it necessary to undertake a conversion of her road vehicles to the less efficient and more cumbersome substitute fuels. It may be mentioned that the same reasoning may explain the delays in the execution of the expansion program for synthetic oil plants. Germany may only have tried during this period -- as was the case in Great Britain -- to perfect the generator and to create a skeleton organization for manufacturing and installing generators, and for supplying fuel. Such a policy would have served as a safeguard against adverse circumstances in the future. Later in the winter of 1941, when Germany realized that her hopes for a quick and successful campaign in Russia were not likely to materialize, all her resources and supplies, her motor repair shops and garages, were so clogged with the repair of army vehicles that no facilities and

manpower could be made available to carry out the generator program. In the summer of 1942 hopes for the conquest of the oil-rich Caucasus again revived and were once more disappointed. Meanwhile Germany's oil position had deteriorated drastically. With no relief in sight every effort had to be made to save liquid fuel by expanding the use of solid fuels. Real progress in the conversion program, therefore, dates from the middle of 1942.

There are numerous additional independent intelligence items which fit into this interpretation, of which only a few are listed below:

1. Schell was relieved of all responsibility for the conversion program and replaced by Speer and Kuhn in the autumn of 1942.

2. A new office, the Central Board for Generators, was established in June 1942 to carry through the conversion program as rapidly as possible.

3. Generator fuel distribution was put on a new and more efficient basis and the coal industry was included in the supply program late in 1942.

4. Regulations to control the additional fire and health hazards created by generators were not issued before the middle of 1942.

5. Special tests to find out whether generator vehicles were winter proof were not undertaken until the winter of 1942.

6. Special training courses for drivers of generator vehicles and special licenses for such drivers did not become compulsory until 1943 (See also Deutsche Bergwerks Zeitung, September 14, 1943 and Oel und Kohle, October 1, 1943).

7. The Essener National Zeitung, June 29, 1942, stated that the conversion of motor vehicles to generators was only then really getting under way.

8. A cable from Bern (October 13, 1943) stated that the experimental work for converting small passenger cars and trucks in Greater Germany to substitute fuels had just been completed. It added that liquid fuel substitutes were being used in Germany at an increasing rate, and that filling stations for solid fuel substitutes were being erected at 50 km. intervals. These measures would have been necessary in 1941 or, at the latest, in 1942, if the number of generator vehicles actually reached 100,000 at that time.

9. Finally up to September 1943 the law only required the conversion of diesel vehicles with a pay load of 2 tons and over, and gasoline engined trucks with 3 tons and over. The number of vehicles in these classes did not exceed 75,000 in 1938. It is unlikely that voluntary conversion of lighter trucks and of private cars exceeded 30-40,000, especially in view of the fact that no really suitable light generators were available before 1943.

For all these reasons it is suggested that our estimates of the number of generator vehicles in use as of June 1943 be based on the statement by Foedisch for July 1942 and by Speer for June 1943. Foedisch's statement, however, referred only to wood using generators, though it also indicates that generators suitable for other fuels (coal, coke, anthracite, etc.) had been developed. It definitely implies, however, that as of June 1942 practically all generators in use utilized wood. The number of generators using other kinds of fuel

probably did not exceed 3-5,000. The total number of generator vehicles as of June 1942 would thus amount to 28-30,000. It is not quite clear whether the total number of conversions mentioned in the Speer speech includes those of military vehicles, but it probably does. It is most likely, however, that the rate of conversion of military vehicles to generator fuels in Germany proper was much slower than it was in some of the occupied countries. In those countries generator equipment, garages, skilled labor, and fuel were available, while in Germany the budding civilian conversion program absorbed all available facilities, and for obvious reasons was given priority over a military conversion program. It is therefore assumed that by July 1, 1943, allowing for a small number of military generator vehicles and for depreciation, about 115,000 civilian vehicles had been converted to solid substitute fuels.

In addition, a large number of vehicles, estimated at 120,000, were using liquid gas (see ~~below,~~ part on liquid fuel consumption) and some 15,000 vehicles other gaseous fuels.

The Number of Civilian Motor Vehicles Using Gaseous Substitute Fuels

A basic article on the development of the use of gaseous substitutes (Permanentgas) written by the former head of the government department charged with their development appeared in the March 1943 issue of Oel und Kohle. It was announced that under the supervision of the Central Board for Generators the following program for conversion to gaseous fuels was to be undertaken in 1943:

By the end of 1943 the completion of 60 existing high pressure gas filling stations and the construction of another 80 are planned. The A.G. der Kohlenwertstoffverbaende will undertake the construction of these filling stations in cooperation with the various urban communities.

Low-pressure gas stations will be erected by the organization of the German bus traffic companies.

In particular the following plan has been drawn up for 1943 for Germany, the Protectorate and the General Government of Poland. Sixty high pressure gas filling stations, each able to supply 70-100 vehicles a day, will be completed. The necessary steel bottles for the conversion of 5,000 vehicles are now available. In the first phase the above mentioned A.G. will complete 26 filling stations; some of these are already in operation. During the second phase another 60 filling stations will be erected. This includes 20 filling stations for sewer gas in Germany and 25 for natural gas in the General Government of Poland. With the completion of this program by the end of 1943, some 20,000 vehicles can be serviced, making possible a saving of about 100,000 tons of liquid fuel. In addition, 2-3,000 busses will have been converted to the use of low-pressure city gas. This will allow a saving of another 20-25,000 tons of liquid fuel yearly, since busses run an average of 40-50,000 kilometers a year. The conversion of the busses will be done in special plants.

Depending on the gas used and on the size of vehicles, 2-6 bottles will be installed in each vehicle, which will provide sufficient fuel for 100 kilometers. In most cases the motors need not be changed as there is no loss of efficiency when methane or sewer gas is used. The loss of motor power when city gas is used is only 10 percent. If such a loss cannot be absorbed, the compression ratio of gasoline engines will be increased to 1:7.5 or 1:8. In the case of diesel engines the motor is changed into a gasoline motor by reducing the compression ratio and by equipping it with a carburetor.

Filling stations for the supply of high pressure gas must include compressor plants, gas purifiers, cooling equipment, transformers, and high pressure storage tanks. Such filling stations actually constitute small factories. From two filling points 250-300 bottles can be filled daily, but it is planned to supply each filling station with 3 filling points in the near future.

The original plans described in the above statement probably had to be revised. The materials and manpower needed for the construction of the filling stations were also urgently required for the construction of synthetic oil plants (see Oel und Kohle, March 1, 1943). Moreover, many of these filling stations were to be erected in Western

Germany and were to use coking gas from the Ruhr district (see Berliner Boersen Zeitung, March 28, 1943). The air raids on the Ruhr must have interfered with this program. The total number of vehicles using gaseous substitute fuels by July 1943 probably did not exceed 15,000 units. It is therefore estimated that not more than 130,000 German vehicles had been converted to the use of solid and gaseous substitute fuels by that date. This figure most probably over-estimates rather than under-estimates the number of road vehicles using substitute fuels. Another 100,000 units were probably still using liquid gas; the total number of civilian motor vehicles using other than light motor fuel or diesel oil may therefore have reached 230,000.

The total number of German motor cars, busses and trucks in use in June 1943 probably did not exceed 530,000 vehicles, of which some 330,000 were trucks and busses, and 200,000 private cars. Finally, 650,000 motorcycles were probably still in use. These figures compare well with the statement in the Luebecker Zeitung, No.77, March 1943, that only 25 percent of all vehicles in operation at that time were operated by producer gas.

Private Motor Vehicles Using Solid and Gaseous Substitute Fuels

The number of private cars converted to solid and gaseous substitutes (excluding liquid gas) by July 1943 was very small indeed. In June and September 1943 regulations were issued by the Reich Traffic Ministry requiring the conversion to substitute fuels of motor vehicles which consumed not more than .3 tons a year (passenger cars, taxis, small delivery cars, hearses) and which were needed for war-work. High pressure gas, liquid gas -- in exceptional cases and if supplies are

available -- charcoal, and wood may be used for cars with a cylinder capacity of less than 2 liters. For cars with a cylinder capacity of 2 to 3 liters any fuel except charcoal may be used. The use of large cars (cylinder capacity over 3 liters) is discouraged by the ruling that they can be converted only in exceptional circumstances. Cars are not allowed to use electricity, low pressure gas, acetylene gas, and trailer borne generators. The subsidies for conversion were raised from 25 percent to 50 percent of the cost. (Rheinische Westfaelische Zeitung, June 1943, Deutsche Volkswirtschaft, July 1943, and Deutsche Allg. Zeitung, October 10, 1943). A generator weighing 35-100 kilograms is now available for this conversion (Bern cable, October 13, 1943). As the conversion of small commercial vehicles has not yet been completed, however, it is doubtful whether the conversion of private cars will make rapid progress during the winter of 1943 (see also Muenchener Neueste Nachrichten, November 3, 1943). In any case, by July 1942 probably not more than 8,000 private cars were using solid substitute fuels (see also British Enemy Oil Intelligence Committee, August 16, 1943).

The number of private cars using gaseous fuel is also very small. In view of the heavy and bulky gas flasks it was actually stated that, in principle, private cars (and trucks of less than 1.5 tons) should not be converted to gaseous fuels (Chemische Technik, August 8, 1942). By July 1943 probably only 2,000 private cars used city or similar gases as motor fuel. At that time the total number of private cars running on gaseous or solid substitute fuels probably did not exceed 10,000 units.

Busses Converted to the Use of Solid and Gaseous Substitute Fuels

In June 1942 Minister Speer ordered that all suitable busses with 25 h.p. and over be converted to substitute fuels. High pressure gas should be used if filling stations were available within 3 kilometers of the place where the vehicle was garaged. Otherwise, solid fuels should be used (Krakauer Zeitung, June 10, 1942). More detailed information was given at a meeting of the organization of German bus enterprises at Wiesbaden in June 1942. It was stated at this meeting that all remaining unconverted busses must be converted to substitute fuels. Exceptions would be made only for busses used in long distance transportation on routes where no filling stations were available. According to the plans half of the total number of busses should use liquid gas and the other half city gas and generator fuel. Initially 1,200 busses were to be converted to low pressure city gas. These would consume about 50 million cubic meters of gas per annum, assuming that 1.6 cubic meters of gas equals 1 liter of gasoline. The conversion costs were estimated at 1,500 Reichsmark per bus. The loss in efficiency resulting from conversion was calculated at less than 10 percent for motors with a compression ratio of 1 to 7. (Verkehrstechnik, June 20, 1942).

Early in 1943 the number of busses to be converted to city gas was placed at 1,500 (British Enemy Oil Intelligence Committee, March 15, 1943). Numerous intelligence items have appeared in the press stating that the busses in several towns have been converted to city gas. The equipment for this conversion was partly secured in France where some 500 Paris busses had been using city gas for a con-

siderable time. Among the towns where such conversion has taken place are: Wiesbaden, Hanover, Nuernberg (Verein Deutscher Ingenieure, January 9, 1943), Frankfurt (Berliner Boersen Zeitung, May 10, 1943), Pirmasens (Press, December 1942), Kassel, Erfurt, Berlin (Deutsche Bergwerks Zeitung, August 27, 1943), (British Enemy Oil Intelligence Committee, January 25, 1943) and Posen (Press, June 1943).

As of April 1943, 450 busses were driven by city gas according to a cable from Stockholm (July 3, 1943). The number of busses using city gas in July 1943 was probably still below 1,000. No intelligence is available on the number of busses converted to solid substitute fuels and their number has tentatively been put at 2,000. We therefore estimate that in July 1943 not more than 3,000 busses were using gaseous and solid substitute fuels. Many of the remaining busses used liquid gas. It has been assumed that most of the substitute fuels using busses formerly consumed gasoline.

The Number of Trucks Using Solid and Gaseous Substitute Fuels

The number of trucks running on solid and gaseous substitute fuels by July 1943 can be established by subtracting the number of converted private cars and busses from the total number of vehicles using these fuels. The number of trucks using solid substitutes in July 1943 can in this way be estimated at 105,000 and those using gaseous fuel at 12,000. An additional 80,000 trucks probably use liquid gas.

By July 1943 the total number of trucks using other than light motor fuel or diesel oil would thus have reached 197,000 units. As the total number of trucks still in use for civilian and industrial

purposes amounted to 320,000, excluding some 25,000 vehicles with electric motors (see part on consumption of liquid fuels), some 123,000 trucks were still running on light motor fuel and diesel oil.

The bulk of the remaining liquid fuel using vehicles consisted of delivery vans, gasoline trucks of less than 3 tons, and private cars which, for technical reasons, had been exempt from conversion to substitute fuels (Frankfurter Zeitung, November 21, 1942 and Deutsche Volkswirt, November 1942). Their conversion became compulsory only in September 1943 (Deutsche Bergwerks Zeitung, October 8, 1943). Practically all suitable diesel vehicles of 2 tons and over and most of the suitable gasoline powered trucks of 3 tons and over have been converted (see also Petroleum Press Service, November 1943, p. 146). It is very unlikely, however, that the plan to convert vehicles using liquid gas to other gaseous or solid substitutes had actually been carried out by July 1943. Intelligence on this question is not available (see part on consumption of liquid petroleum products).

It is tentatively estimated that of the 117,000 substitute fuel using trucks, 16,000 were formerly diesel engined and 101,000 gasoline engined (see part on consumption of liquid fuels). Converted diesel trucks consume diesel oil to the extent of about one-third of their total fuel consumption (in terms of liquid fuel). Converted gasoline trucks need light motor fuel for quick starting and for up hill climbing and other driving where extra power is needed. It has been assumed that on an overall basis 5 percent of their total fuel consumption (in terms of liquid fuel) is still light motor fuel.

Production and Distribution of Substitute Fuels

In June 1942 the Central Board for Generators was created and charged with the following functions: (1) to organize mass production of simplified types of generators, (2) to supervise and direct the conversion of the bulk of all liquid fuelled engines, and (3) to provide for the supply and distribution of substitute fuels (Berliner Boersen Zeitung, September 5, 1942).

One of the first steps taken by the Board was the reorganization of the Generatorkraft A.G. which since 1941 had held a distribution monopoly for substitute fuels (Deutsche Volkswirt, December 12, 1942). Its share capital was raised from 1.8 million Reichsmark, mostly owned by the timber industry, to 9 million Reichsmark (Berliner Boersen Zeitung, December 4, 1942). Of the increased capital 50 percent was taken over by the Ruestungskontor, 22.5 percent by the Reichsvereinigung Kohle, 10 percent by timber interests and most of the remaining capital by oil companies (Neues Wiener Tagblatt, February 5, 1943).

As available supplies of wood were woefully inadequate for a large scale conversion, greater reliance was to be placed on the use of coal and coke. Through the participation of the coal trade in the supply of substitute fuels, it was planned to raise the number of distributing stations from 600 to 2,000. (Berliner Boersen Zeitung, September 17, 1942). In addition, the "Festkraftstoff A.G." was created to encourage and if necessary to undertake the production of solid substitutes, especially from new materials.

As of July 1942 the building of new wood generators had

actually ceased and new generators had to be adapted to the use of anthracite, coal, coke-briquettes, or peat. Though timber production in 1943 had increased to 70 million cubic meters and was expected to rise to 80 million cubic meters in 1944 -- as compared with 48 million cubic meters in 1934 (Deutsche Volkswirtschaft, October 1943) -- it proved absolutely impossible to allocate more than 4-5 million cubic meters of suitable and conveniently located wood to the use of generators. Supplies of anthracite were limited to about 100,000 tons a year, produced largely in a few mines in Western Germany. Suitable supplies of peat amounted to no more than 40-60,000 tons; and it may be noted that the use of peat presented great problems since peat must be properly dried for many months before it can be used. A new company, the "Torfkraftstoff A.G.", was founded by the "Festkraftstoff A.G." in 1943, mainly for the purpose of developing the use of peat coke, based on the peat deposits of Eastern Europe (Deutsche Volkswirtschaft, 1943, No. 28). The main hopes had, therefore, to be placed on the development of generator briquettes from coal and on lignite coke. A new company, the "Prolignite A.G.", was formed in Cologne, with a capital of 1 million Reichsmark (Oel und Kohle, August 1943) to produce large quantities of lignite coke. In the summer of 1943 Speer stated that a by-product of synthetic oil production, obviously some kind of coke, was to be used in increasing quantities.

In April 1943 it had become necessary to submit supplies and distribution of solid fuels to strict government control. Distribution was reorganized and the so called "Festkraftstoffkarte" was introduced.

It prescribed for each user the kind of substitute fuel he could use and the filling station at which he could buy it. Each purchase was to be registered on the card. Long distance road transportation was discouraged by limiting the validity of these cards to filling stations within 50 kilometers of the usual location of the vehicles (Deutsche Allgemeine Zeitung, March 24, 1943).

Total Saving of Liquid Fuel by the Use of Substitutes

It is very difficult to estimate the quantities of liquid fuel saved in 1943 by the use of gaseous and solid substitutes. Five important factors have to be considered:

1. the supply of solid fuels was limited and distribution was by no means perfect;

2. the tight rubber position definitely imposed additional limitations on road transportation;

3. the annual ton mileage which can usually be achieved with a generator vehicle is lower than that of a vehicle using liquid fuel;

4. as against these factors it has to be borne in mind, however, that the supply of solid and gaseous fuels was still somewhat better than that of liquid fuels (see Deutsche Volkswirt, November 1, 1942); and

5. most of the vehicles converted up to July 1943 were heavy vehicles with a correspondingly high rate of unit requirements.

After weighing these various considerations it is assumed that converted gasoline vehicles are about two-thirds as active as they were before the war, or, in other words, that the saving of light motor fuel achieved by conversion is about two-thirds the peace time

consumption by these vehicles, or about 4 tons per vehicle. This does not allow for the 5 percent liquid fuel requirement after conversion, so that the net saving of liquid fuel is about 63 percent. Net savings in the case of diesel vehicles are assumed to be about four-ninths of their former consumption, or 4 tons, a figure which is reached by assuming that the reduction in activity is about one-third and that after conversion diesel trucks still require 2 tons of diesel oil per year.

The viscosity of lubricating oil used in generator vehicles tends to increase under the influence of sulphur and dust and lubricants must therefore be changed more frequently than in motors using liquid fuel. In the case of solid fuels, lubricating oil requirements have been estimated at 5 percent by weight of the liquid fuel equivalent of the solid fuels consumed. Slight variations in lubricating oil requirements for the different solid fuels are ignored. For gaseous fuels a ratio of 3 percent by weight was used. (see also Generator Jahrbuch, p. 27).

The Use of Generator Motors on Railroads

There is very little intelligence on the use of substitute fuels in rail cars and diesel locomotives. It is known, however, that a large number of gasoline engined rail cars use liquid gas (Generator Jahrbuch, 1942, p. 89). As late as November 1942 the technical problem of converting diesel rail cars to substitute fuels had not been completely solved. The great horsepower of such rail car engines (200-650 h.p.) created serious problems. Normal truck generators could not be used and stationary generators were too bulky and weighty

(Generator Jahrbuch, 1942, p. 119). Liquid gas was used by small and a few medium-sized diesel rail cars. It was planned to use solid substitute fuels together with diesel oil for the remaining medium-sized and large diesel rail cars (Generator Jahrbuch, 1942, p. 110). Subsidies for such conversions were promised in September 1943 (Deutsche Bergwerks Zeitung, October 3, 1943).

The conversion of switching engines to solid fuels created another set of problems; in the course of normal operations the engines must stop frequently and pull greatly varying loads. Wood proved unsuitable for these engines (Generator Jahrbuch, 1942, p. 112-113), but some success has been achieved with l.t.c. lignite coke. Because of these difficulties, the production of new oil using switching engines was continued until June 1942.

It has been assumed that most of the rail car requirements of light motor fuel and probably one-third of the requirements of diesel oil have been replaced by liquid gas. Another one-third of the former diesel oil requirements have probably been replaced by solid fuel and diesel oil in the proportion of 2 to 1, or a net saving of two-ninths.

The Use of Generator Motors in Shipping

Not much is known about the actual progress made in the conversion of inland and coastal shipping to the use of substitute fuels beyond the information contained in the somewhat discredited speech made by Schell in September 1941. In this speech Schell stated that 90 ships were already driven by generator gas and that another 125 vessels with a total h.p. of 35,000 would be converted soon. On the whole, it is planned to convert 1,200 ships or some 40 percent of all

motor ships.

Because of the great delays experienced in the conversion program in general and the technical difficulties involved in adapting generators to ships in particular, the Schell program has in all likelihood not yet been completed. In October 1943 it was reported that marine diesel engines were to be replaced by producer gas equipment in order to enable ship owners to use their ships to the utmost capacity. Grants covering the full cost of conversion will be made and ration cards for solid fuels will soon be issued for inland vessels (Petroleum Press Service, October 1943). If it is assumed that half of the Schell program had actually been carried out by the middle of 1943, some 600 ships would have been equipped with generators. At an average of 90 h.p. per ship the horsepower of ships converted to substitute fuels would correspond to about 15 percent of all inland shipping. About one-fourth of the total fuel requirements (in terms of liquid fuel) of converted diesel ships will still consist of diesel oil. The quantities saved by the use of solid substitute fuels in inland shipping in 1943 are therefore estimated at some 15,000 tons (see OSS report on civilian consumption of liquid fuel and substitutes in 1942, p. 24).

Generator Motors for Coastal Shipping and Fishing

In April 1943 the Commissary for Shipping asked all owners of seagoing and coastal vessels to inform him of the steps being planned by them for the conversion of their boats to generator fuel. The owners were informed that all ships except those with less than 50 or more than 1,000 h.p. would have to be converted ultimately. (Hamburger Fremdenblatt, April 21, 1943). Subsidies for the whole cost

of conversion will be granted (Deutsche Bergwerks Zeitung, August 27, 1943). Liquid fuel rations of owners who do not comply with this decree will be cancelled. By June 1943 not much progress could possibly have been made with the conversion program initiated in April. It has been stated that the conversion will not be carried through on a large scale before September 1943 (Oel und Kohle, September 15, 1943).

The Use of Generators in Agriculture

There exists considerable incidental intelligence that the program for converting agricultural tractors as outlined in the Schell speech of September 1941 had lagged as much behind the original plan as that for converting road vehicles. Not before early 1942 did newspapers report that an efficient generator for tractors had been developed. At the same time it was stated that all of the 120,000 tractors in use in Germany which were suitable for conversion to gaseous and solid fuels would have to be converted; from the summer of 1942 onwards, it was added, only generator type tractors would be built -- mostly, however, for use in Occupied Russia -- (Deutsche Volkswirtschaft, 1942, p. 173).

Towards the middle of 1942 the German press described vividly the enormous difficulties confronting the conversion, such as special technical problems, lack of skilled drivers, loss of power in converted tractors, difficulties in the production and distribution of fuel, etc. (Verein Deutscher Ingenieure, June 13, 1942). On December 14, 1942 detailed regulations were published for the conversion of tractors and other agricultural machines (Reichsanzeiger, 1942, No. 293, and Neues Wiener Tagblatt, December 18, 1942). According to

this decree the conversions had to be made to save liquid fuel and to utilize tractors more profitably. A subsidy was to be granted, which would vary with the type of tractors. The use of liquid gas and of high or low pressure gas was permitted in exceptional cases only (Verein Deutscher Ingenieure, March 6, 1943). The fuel to be used in most cases was wood or peat from the farmer's own production, or lignite briquettes which were to be supplied by the Generatorkraft A.G. The generators had to be models capable of using all these three fuels.

The local fuel offices were to direct the conversion of tractors and to decide which tractors should be converted and when. A special permit was necessary for voluntary conversion of tractors. Other agricultural motors which normally consumed more than 400 kg. of diesel oil or 500 liters of gasoline, kerosene or other tractor fuel were also to be converted to other sources of power, such as generator, electric, steam, or city gas fuelled motors, etc.

By July 1943 obviously only a limited number of tractors had been converted to substitute fuels, since very few conversions would have taken place during the spring (see also British Enemy Oil Intelligence Committee, November 22, 1943). The problem of supplying fuel, either coal or wood (a tractor of 20 to 50 h.p. needs 22 to 44 cubic meters of wood a year, an amount equal to the output of fire wood from 60 to 75 acres of forest) imposes further limits to a large scale conversion. Including newly manufactured generator tractors, the total number of substitute fuelled tractors by July 1943 probably did not exceed 20,000 of which an estimated 10,000 were formerly diesel engined and 10,000 gasoline engined. Recent reports indicate that

preparations have been speeded up and that the conversion of most of the agricultural tractors to substitute fuels by the spring of 1944 is hoped for (Petroleum Press Service, October 1943).

Converted diesel tractors will need some 25 percent of their total fuel requirements (in terms of liquid fuel) in the form of diesel oil. The average fuel consumption of a gasoline engined tractor for 800 working hours a year has been put at 4 tons, and that of a diesel tractor (with a higher average horsepower) at the same figure. According to a German periodical (Verein Deutscher Ingenieure, June 13, 1942) the average requirements of a medium-sized diesel tractor amount to 5 tons a year; but this figure also includes the fuel requirements for tractors used in road haulage and for the supply of power on the farms. The total quantities of liquid fuel saved by the conversion of tractors to substitute fuels may be put at 40,000 tons of light motor fuel and about 30,000 tons of diesel oil.

In addition, savings were achieved by the conversion of agricultural machines to electricity and to other sources of power. A subsidy of 50 percent of the cost involved was granted for such conversions (Essener National Zeitung, January 11, 1942). In March 1942 it was estimated that 15,000 oil motors, with a total horsepower of 145,000, had been replaced by electric motors, which made possible a saving of 8-10,000 tons of liquid fuel per annum (Wirtschaftsring, March 13, 1943). By June 1943 savings probably reached 15,000 tons. A higher rate of conversion to the use of electricity was probably impossible as the electrical equipment industry was unable to supply large quantities of new electric motors. Moreover, only those farms

which had power connections could make use of electric motors.

The total savings of liquid fuel in agriculture in 1943 probably did not exceed 85,000 tons.

The Use of Substitute Fuels in Industry

The conversion of industrial motors to substitute fuels has been subject to as much if not more delay than that of motors used in other parts of the economy. In 1941 a subsidy was promised for the conversion of stationary diesel engines using less than 12 tons of diesel oil a year to other kinds of fuel (Petroleum Press Service, September 1941). An order of May 1942 required the conversion of all industrial motors driven by liquid fuel to generator operation by April 1943 and promised financial assistance for this conversion. A new order, however, was issued in May 1943 extending the period of conversion to May 31, 1944 and raising the financial assistance to 25 percent of the conversion costs up to a maximum of 5,000 Reichsmark (British Enemy Oil Intelligence Committee, June 26, 1943).

In June 1943 Speer again decreed that all stationary motors would have to be converted to gaseous or solid substitute fuels if steam, or electricity, or water power could not be used instead. At the same time, the upper limit for the subsidies was raised from 5 to 10,000 Reichsmark (Bern Cable, July 12, 1943). Similar subsidies were promised in September 1943 for the conversion of motors used in the building industry (Deutsche Bergwerks Zeitung, October 3, 1943).

There have been few reports on the actual progress of conversion to gaseous and substitute fuels in industry by the middle of 1943. Actually most of the savings were achieved by using liquid gas

wherever possible. The use of gaseous and solid substitute fuels in industrial motors in 1943 probably resulted in savings of less than 5 percent of the 1938 industrial requirements of light motor fuel and Diesel oil. This figure would also include the savings achieved by using substitute fuels for the breaking in of new engines (see, e.g., Oel und Kohle, March 8, 1943).

III. THE USE OF SUBSTITUTE FUELS IN THE PROTECTORATE AND SLOVAKIA DURING 1943

PROTECTORATE

Road Transportation

In general the same regulations which applied to the use of substitute fuels in Germany were also in force in the Protectorate. A special committee was formed early in 1942 to cooperate with the German authorities in the conversion of liquid fuel using vehicles. By June 1943 most of the trucks and busses probably used either producer gas or, to a limited extent, city gas and liquid gas. (see British Enemy Oil Intelligence Committee, July 19, 1943.) The few private cars and taxis which were still in use were mostly driven by liquid gas, or were being adapted to the use of solid fuels (British Enemy Oil Intelligence Committee, July 19, 1943). Occasionally, new city gas filling stations are being opened (see, e.g., Der Neue Tag, December 13, 1942).

For lack of detailed intelligence the number of motor vehicles in use and the number of vehicles converted to substitute fuels has been calculated as the same percentages of the prewar figures as in Germany.

Railways, Shipping, Agriculture and Industry

Similar assumptions were made for estimating the use of substitute fuels in railways, shipping, agriculture, and industry. This assumption is based on the fact that the set of regulations governing the conversion of liquid fuel using motors to substitutes in the various branches of the economy is in general similar to the decrees issued in the Reich. Late in 1942, e.g., it was decreed that all agricultural tractors must be fitted immediately with producer gas units and that

subsidies for the conversion would be granted by the Ministry of Agriculture (Suedost Echo, December 25, 1942, and Der Neue Tag, July 25, 1943). The construction of new liquid fuel using locomotives was also prohibited and generator locomotives using charcoal were developed (Der Neue Tag, April 14, 1943). Rail cars were equipped with charcoal generators (Verein Deutscher Ingenieure, September 5, 1942). All combustion engines in industrial plants and factories were to be adapted to mechanical or gas drive. Finally a Central Board for Generators was established in February 1943 (Der Neue Tag, February 4, 1943).

SLOVAKIA

Road Transportation

Towards the middle of 1942 a decree was issued in Slovakia according to which owners of liquid fueled motors used for road transportation, railways, shipping, and stationary sources of power could be compelled to convert these motors to substitute fuels (Nachrichten fuer den Aussenhandel, October 14, 1942). In August 1942 it was reported that 1,200 to 1,500 trucks of over 2 tons capacity would be converted to generator fuel (Oel und Kohle, August 3, 1942). Somewhat later it was stated that all busses and about 200 private cars in Bratislava were using substitutes (British Enemy Oil Intelligence Committee, May 17, 1943). Early in 1943 it was reported that half the motor vehicles of the country would be converted to substitute fuels in 1943 (Oel und Kohle, February 22, 1943).

An important factor delaying conversion was the scarcity of generators, most of which had to be imported from Switzerland (British Enemy Oil Intelligence Committee, May 17, 1943). Initially, supplies of fuel -- wood and charcoal -- were relatively ample. In 1940 charcoal production amounted to 40,000 tons and in 1943 output was more than 80,000 tons. About 75 percent of the total production, however, was exported (Deutsche Bergwerks Zeitung, April 14, 1943 and Chemische Zeitung, June 1943). The growing production of charcoal led to a wood shortage in 1943. In September 1943 the distribution of generator fuel was reorganized and the creation of a distribution monopoly was planned (Press, September 1943).

By July 1943 1,200 trucks and half of the busses and private cars in use had probably been converted to substitute fuels. Severe

restrictions on all non-essential transportation using substitute fuel, as well as on that using liquid fuel, were imposed in the autumn of 1943, indicating that even the supply of substitute fuels was insufficient (Oel und Kohle, October 1, 1943). The progress of conversion to substitute fuels in railways, agriculture, and shipping has most likely been at a low rate until at least the present time.

IV. THE USE OF SUBSTITUTE FUELS IN ITALY DURING 1943[1]

Road Transportation

The development of generator vehicles in Italy was hampered by the lack of suitable fuels. Supplies of solid fuels were limited, and bottlenecks in distribution and labor prevented any large expansion of use. Moreover, because of Italy's small domestic coal and wood supplies, timber and charcoal were needed for essential heating, cooking, and construction purposes.

A most important domestic fuel was methane gas, obtained mainly from the wells of Northern Italy. In the autumn of 1941, according to the President of the Ente Nazionale Metano, 20,000 vehicles were operating on methane gas (Bern Cable, August 8, 1942), as against 4,300 at the end of 1940. Another 10,000 vehicles were probably using solid fuels. Most of the vehicles using methane gas were stationed in Northern and Central Italy.

Not much progress in substitution could ~~probably~~ have been made during the next 18 months. By July 1943 there were probably not more than 40,000 vehicles using substitute fuels, of which 25,000 may have used methane gas and 15,000 solid fuels (see OSS report, October 2, 1943). The following vehicular breakdown has been tentatively estimated:

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[1] Italy, as used in this study, includes Italy, Sicily, and Sardinia up to July 1943, the Italian mainland for the month of July and August, and about two-thirds of the Italian mainland for the rest of the year.

NUMBER OF VEHICLES USING SUBSTITUTE FUELS AS OF JULY 1943

	Gaseous	Solid
Private Cars	6,000	2,500
Busses	2,500	1,500
Trucks	16,500	11,000
TOTAL	25,000	15,000

Solid as well as gaseous fuels have been rationed for some time. Solid fuel rationing was introduced in February 1942; as far as it is known, rations have been maintained at the same level ever since.

MONTHLY RATIONS OF SOLID SUBSTITUTE FUELS

(in kilograms)

	Charcoal	Wood
Private cars	150	300
Trucks up to 15 h.p.	200	600
Trucks between 16 and 20 h.p.	350	700
Trucks between 20 and 30 h.p.	750	1500
Trucks between 30 and 40 h.p.	2000	4000
Trucks over 40 h.p.	4000	8000

Total 1943 wood consumption on the basis of the above vehicular figures and rations amounted to probably 100,000 tons of wood and 50,000 tons of charcoal. This figure compares with requirements of 500,000 tons of charcoal for cooking and heating.

Lubricating oil was rationed at 750 grams per 100 kilogram of charcoal used and at 500 grams per 100 kilogram of wood.

NUMBER OF VEHICLES USING SUBSTITUTE FUELS AS OF JULY 1943

	Gaseous	Solid
Private Cars	6,500	2,500
Busses	1,500	1,500
Trucks	17,000	11,000
TOTAL	25,000	15,000

Solid as well as gaseous fuels have been rationed for some time. Solid fuel rationing was introduced in February 1942; as far as it is known, rations have been maintained at the same level ever since.

MONTHLY RATIONS OF SOLID SUBSTITUTE FUELS

(in kilograms)

	Charcoal	Wood
Private cars	150	300
Trucks up to 15 h.p.	200	600
Trucks between 16 and 20 h.p.	350	700
Trucks between 20 and 30 h.p.	750	1500
Trucks between 30 and 40 h.p.	2000	4000
Trucks over 40 h.p.	4000	8000

Total 1943 wood consumption on the basis of the above vehicular figures and rations amounted to probably 100,000 tons of wood and 50,000 tons of charcoal. This figure compares with requirements of 500,000 tons of charcoal for cooking and heating.

Lubricating oil was rationed at 750 grams per 100 kilograms of charcoal used and at 500 grams per 100 kilogram of wood.

Available supplies of gaseous fuels can be estimated on the basis of a speech by the President of the Ente Nazionale Metano early in 1942. He stated that the production of methane gas amounted to 5 million cubic meters a month and was increasing at the rate of 100,000 cubic meters a month. Most of the output (some 4 million cubic meters a month) came from the Po Valley (Bern Cable, July 4, 1942). In addition, some 700,000 cubic meters were obtained from coke ovens and very small quantities from sewer gas. (Since the autumn of 1941 all towns with a population of over 100,000 have had to recover methane gas from sewer gas.) The total production of methane gas in 1942 may be estimated at 60 million cubic meters equivalent to about 40,000 tons of gasoline. Not all of this production, however, was available for automotive purposes. Part of it was consumed in industry (Oel und Kohle, March 3, 1943 and Nachrichten fuer den Aussenhandel, September 1, 1942).

Limitations on a rapid expansion of the use of methane gas were imposed by difficulties of distribution, especially by the scarcity of steel bottles. It was hoped that some of these difficulties might be overcome by the construction of pipelines from the wells to the important consuming centers and by the erection of a network of high pressure gas filling stations. Early in 1943 it was reported that the following pipelines were in operation (British Enemy Oil Intelligence Committee, May 10, 1943):

1. Tabiano to Salsomaggiore
2. Podenzano to Piacenza
3. Fonteviva - Bellena to Via Emilia

In addition, the following pipelines were under construction:

1. Porretta district to Bologna
2. S. Giuseppe di Cairo to Turin and Milan
3. Porto Marghera to Ferrara and Bologna

A 40 mile pipeline between Piacenza and Milan was reported in use towards the middle of April 1943 (Frankfurter Zeitung, April 14, 1943). Total available supplies of methane gas in 1943 have been estimated at about 70 million cubic meters.

The monthly methane gas rations towards the middle of 1943 were as follows:

MONTHLY RATIONS OF METHANE GAS

(in cubic meters)

	Middle of 1943	November 1941
Motor cars and motorboats	40	60
Taxis in towns up to 100,000 inhabitants	100	100-200
Taxis in towns between 200-300,000 "	150	
Trucks over 30 h.p.	?	200

Lubricants were rationed at 1 kg. per 100 cubic meters of methane gas used. Busses in public road services were allowed about 25 percent more lubricants per unit of fuel.

Railways

The use of oil driven rail cars was abandoned at the outbreak of war. Recent reports, however, suggest that some of them have been converted to the use of substitute fuels. A compressing station for methane gas at Rovigo was reported to supply the equivalent of 2,000 tons of liquid fuel a year to rail cars (Oel und Kohle, April 8, 1942). On the whole, it has been assumed that in 1943 some 3,000 tons or 30 percent of the 1938 motor fuel requirements of railways were replaced by gaseous and solid substitutes.

Shipping

Early in 1942 measures were taken to equip vessels with wood generators. Some experiments were actually made, but nothing further is known about the progress of conversion. (Neues Wiener Tagblatt, May 21, 1942). The number of ships actually converted is probably insignificant.

Agriculture

The number of registered agricultural tractors in 1939 amounted to 19,237. In addition, there were some 50,000 tractors which had not been registered and 10,000 stationary agricultural oil using machines (British Enemy Oil Intelligence Committee, March 29, 1943). Of the total number of tractors, only some 30,000 were suitable for conversion to substitute fuels. Early in 1943, a four-year conversion plan was promulgated. The conversion was to be done province by province, beginning with the conversion of 200 tractors in the province of Rome (Voelkischer Beobachter, February 12, 1943). Later in 1943 another decree was passed ordering the conversion of all farm tractors to the use of methane gas within the next 6 months. The armament industry was charged with providing the necessary equipment (Oel und Kohle, August 1943, and Neues Wiener Tagblatt, July 1, 1943). Such a task, however, was obviously beyond the realm of probability and this decree can only be interpreted as a panic measure. For the whole of 1943 the quantities of liquid fuels replaced by substitute fuels was probably less than 5 percent of prewar agricultural consumption.

Industry

No intelligence is available on the use of substitute fuels

for industrial motors. Some methane gas will, however, have been used locally.

V. THE USE OF SUBSTITUTE FUELS IN HUNGARY DURING 1943

Road Transportation

Though Hungary's domestic crude oil production exceeded total requirements by a large margin, strenuous efforts were made to convert motor vehicles to the use of substitute fuels in order to increase the exportable surplus of liquid fuel. A decree was passed in May 1943, requiring that all vehicles converted to producer gas must retain their liquid fuel equipment in good condition, so that immediate re-conversion to gasoline could take place (Oel und Kohle, July 1, 1943). At that time the process of conversion to solid fuels was most likely still in its first phases, even though, under German pressure, a conversion program had been decided upon for some time.

Somewhat earlier a limited number of vehicles had been converted to the use of propane, butane, and natural gas (Nachrichten fuer den Aussenhandel, August 10, 1942). Such conversions, however, could only be made with the special permission of the authorities. Available quantities of gaseous fuel and the number of steel bottles were both limited. Early in 1943, the Hungarian Natural Gas Valorisation Company, which was charged with the production and distribution of gaseous fuels, stated that it supplied liquid gas to only 600 vehicles (Petroleum Times, April 17 and June 26, 1943). Plans were made in October 1943 to use increased quantities of compressed natural gas from Transylvania to replace liquid motor fuel (Oel und Kohle, November 1, 1943). The Transylvanian Natural Gas Company was founded for that purpose (Deutsche Volkswirtschaft, October 1943).

Solid fuel supplies were also limited. In 1940 the output

of charcoal amounted to 25,000 tons and in 1941 to 20,000 tons; a further decline took place in 1942. Because wood was needed for domestic heating purposes, the number of licenses for the production of charcoal were actually reduced (Nachrichten fuer den Aussenhandel, August 17, 1942), and output fell short of demand (Deutsche Bergwerks Zeitung, October 24, 1943). Small quantities of lignite and wood were also used as generator fuel (Oel und Kohle, November 1943).

The total number of vehicles converted to gaseous and solid substitute fuels as of July 1943 was very small, probably not exceeding 1,500 vehicles. This total includes some 250 of the 750 Budapest taxis (Oel und Kohle, August 19, 1942 and British Enemy Oil Intelligence Committee, August 16, 1943). In addition, some private cars in the gas producing regions and some trucks, where local supplies of substitute fuels were available, were converted. Solid fuels were probably used to some extent, especially in Transylvania.

Railways, Shipping, Agriculture, Industry and Household

There is no intelligence which indicates that substitute fuels were used in other branches of the economy besides road transportation.

VI. THE USE OF SUBSTITUTE FUELS IN BULGARIA DURING 1943

Road Transportation

Until very recently conversion to generator vehicles in Bulgaria had been much slower than in most other countries. Early in 1943 it was reported that generator vehicles were not much in evidence in Bulgaria. This can partly be explained by the difficulties experienced in importing generators from Germany, by the high prices asked for the equipment, and by the excessive cost of converting a vehicle.

In May 1943 it was reported that the German Commissioner for the Conversion of Motor Vehicles to Generator Propulsion in Southeastern Europe would visit Sofia to initiate a systematic conversion of Bulgarian motor vehicles (Nachrichten fuer den Aussenhandel, May 7, 1943). During the first half of 1943 import duties on generators were reduced and subsidies were promised for part of the conversion costs. Steady progress has been reported since the middle of 1943 (Oel und Kohle, June 1943). In October all import duties on generators were cancelled (Oel und Kohle, November 1, 1943). It was announced that by the end of the year all private cars would have to be converted to the use of substitute fuels (Petroleum Times, November 27, 1943, p. 652). A limited number of motor vehicles is also using gaseous fuel.

It has been tentatively estimated that by the middle of 1943 1,250 out of 2,500 trucks, 450 out of 900 busses, and 250 out of 2,500 private cars had been converted to substitutes (see British Enemy Oil Intelligence Committee, May 2, 1943).

Agriculture and Industry

Not much advance has been made in the conversion of agricultural

and industrial machines. This is evidenced by the maintenance of liquid fuel allocations for agricultural purposes and by statements as late as June 1943 that the conversion of municipal power plants to generator propulsion was still under consideration (Nachrichten fuer den Aussenhandel, May 6, 1943). Only at the end of July 1943 did the government finally agree to grant loans for the conversion of Diesel engines used in industry, power plants, and road transportation (Oel und Kohle, September 5, 1943).

VII. THE USE OF SUBSTITUTE FUELS IN FINLAND DURING 1943

Road Transportation

The bulk of the country's civilian road transportation has been converted to substitute fuels, chiefly wood and charcoal, and to a minor extent, gaseous fuels. Early in 1941 a decree was promulgated prohibiting the use of liquid fuels for road transportation and agriculture (for full report on the background see OSS report on "Civilian Consumption of Petroleum in Axis Europe, 1942"). However, despite the existence of abundant resources of wood there was always a definite shortage of producer gas fuel because of insufficient labor and transportation and lack of drying facilities. New state owned companies were formed to increase the substitute fuel supply (British Enemy Oil Intelligence Committee, May 24, 1943, and Oel und Kohle, July 1, 1943). In spite of all efforts fuel production has continuously fallen short of planned output; only in the winter of 1943 has the supply position for generator fuels eased up somewhat. The utilization of the converted vehicles has remained, therefore, considerably below the optimum level.

No recent data on the number of substitute using vehicles are available. In August 1940 the total number was given as 2,600, of which 1,700 were trucks, 600 busses, 32 tractors, and 252 private cars. The potential production of generators was put at 600 per month. By the middle of 1941 it was planned to use some 10,000 converted motors, a figure which was probably not reached before the end of 1942. The production of generators, as well as the output of charcoal, was a limiting factor. By the middle of 1943 the number of converted vehicles

is unlikely to have exceeded 12,000, including tractors. The number of liquid fuel using vehicles may be tentatively put at 6,000 trucks, 1,000 busses, and 2,500 private cars.

Agriculture and Industry

The number of tractors used in agriculture and forestry which were converted to substitute fuels by early 1943 amounted to 3,000 out of a total of 6,200 (Deutsche Volkswirt, April 1943). However, out of the total of 6,200 only 3,500 tractors were suitable for conversion (Oel und Kohle, April 1942). By June a total of 3,300 tractors had probably been converted to substitute fuels.

Most of the liquid fuel driven motors in industry have also probably been converted to substitute fuels, or replaced by electric motors, etc.

Quantities of Liquid Fuel Saved

The total quantities of liquid fuel saved by the use of substitute fuel can be roughly estimated on the basis of the quantities of solid fuels actually available. The total saved would amount to about 35 ~~30~~,000 tons per year, or not more than 50 percent of the planned savings (see Chemische Technik, August 21, 1942 and Nachrichten fuer den Aussenhandel, July 29, 1942).

Section B

THE USE OF SUBSTITUTE FUELS IN THE OCCUPIED COUNTRIES OF WESTERN AND NORTHERN EUROPE, 1943

VIII. THE USE OF SUBSTITUTE FUELS IN FRANCE DURING 1943

Road Transportation

The number of generator vehicles in France by the end of 1942 has been reported in the French and German Press to be 101,318 compared with 70,000 by the end of 1941 and 7,500 by the end of 1940 (British Enemy Oil Intelligence Committee, June 7, 1943). (See also reports by the president of the French Comité Général des Carburants de Remplacement, quoted on page 6 of this study, who stated that the number of substitute vehicles in France at the end of 1941 amounted to 100,000 units.) Of this total of 101,318, it was reported that 57,158 were stationed in Northern France and 44,160 in Southern France (Deutsche Bergwerks Zeitung, April 30, 1943). An additional 15,000 vehicles were to be converted early in 1943.

Besides the vehicles driven by solid substitute fuels there were in April 1943, 20,600 units driven by gaseous fuels, as against 12,900 vehicles in April 1942 (British Enemy Oil Intelligence Committee, November 29, 1943). Gaseous fuels were preferred for busses and small trucks, but were used only to a limited extent in private cars. (In the summer of 1942 some 500 Paris busses were running on city gas, according to Verkehrstechnik, June 20, 1942.) Solid fuels were mostly used in trucks.

Nearly all civilian and industrial transportation was carried out by substitute using vehicles. In 1942, according to a speech by Speer, converted French vehicles representing one-fifth of the total number of motor vehicles traversed the same monthly total mileage as the remaining four-fifths which used liquid fuels (National Zeitung,

November 1, 1942).

Of the 100,000 generator vehicles, some 70,000 used charcoal while most of the rest used wood. Only a few were adapted to coal, coke, and peat (Bern Cable, March 1943; Deutsche Bergwerks Zeitung, October 31, 1943). The use of acetylene was prohibited, even though taxis in Paris had been using this fuel for some time (Oel und Kohle, September 1943). All substitute fuels with the exception of city gas were severely rationed.

Supplies of charcoal and wood have never been sufficient to cover all essential requirements; charcoal production, in particular, has remained far below demand. In 1942 the conversion of vehicles to charcoal was actually prohibited and only the construction of wood, peat, coal, and coke using generators was permitted. Charcoal production in 1943 is estimated at about 450,000 tons by the president of the Comité Général des Carburants de Remplacement, but other estimates have placed charcoal production in 1942 at about 200,000 tons. (Official of a French Oil Company quoted in the British Enemy Oil Intelligence Committee, September 20, 1943; see also Petroleum Press Service, November 1943, page 151.) Actual production of charcoal during 1943 probably fell short of 200,000 tons. The supply position north of the Loire was somewhat easier than in the south, where production was hampered by the lack of timber, scarcity of labor, and difficulty of transportation. Of the 100 new factories for the production of charcoal planned in July 1941, only 65 had been completed by the middle of 1943. In addition, the charcoal was of widely varying quality despite continuing efforts to standardize production (Oel und Kohle, September 1, 1943) and to control and co-ordinate the sales of charcoal.

A Regulating Committee for substitue fuels and lubricants, superseding all similar bodies formed since July 1941, was created early in 1943 (Petroleum Press Service, February 1943). A new company for the distribution of substitute fuels under the supervision of the government was also established, the Comptoir National d'Achat et de Distribution du Charbon des Bois et des Combustibles pour Gazogènes. Its capital amounts to 1 million francs and the important oil companies participate in it (Oel und Kohle, September 15, 1943).

In 1942 88 million cubic meters of city gas (out of a total production of 200 billion cubic meters) were used by vehicles converted to gaseous fuels, thus replacing some 35,000 tons of liquid motor fuel (Oel und Kohle, May 1, 1943). On the basis of the increase in the number of converted vehicles from 1942 to 1943 probably some 60,000 tons of motor fuel were replaced by city gas in 1943. Early in the year there were 100 filling stations for city gas as against 90 in 1942 (Bern Cable, March 1943). The number of stations which were actually planned for early 1943 was 170 (Chemische Industrie, July 21, 1942).

The production of generators was standardized in 1942. Originally there were 400 recognized manufacturers (Stockholm Cable, August 26, 1943). A re-organization was then (1942) effected and the Commission Technique des Gazogènes was formed to standardize equipment and to develop generators for agricultural uses, shipping, etc., and to provide subsidies for conversion. The number of manufacturers was reduced to 138, producing 10 types of wood and 9 types of coal generators.

Railways

Detailed information on the conversion of rail cars to sub-

stitute fuels was given in a lecture by the head engineer of the French railways in the summer of 1943 (Deutsche Bergwerks Zeitung, September 2, 1943). Pre-war liquid fuel consumption by the railroads amounted to 55,000 tons. Experiments were made with the aim of replacing this amount by the use of alcohol, electric batteries, etc. None of these efforts were particularly successful. In Southern France some rail cars used the natural gas produced near Toulouse. Special compressor stations had to be built, however, before the gas could be used. About 100 of the 400 rail cars with low-powered motors (25-40 h.p.) were converted to the use of generator fuels by the summer of 1943; the remaining 300, it was said, were to be converted soon. Great difficulties were encountered in the case of engines of 50-200 h.p. Towards the middle of 1943, fifty 50 h.p. engines were being equipped with wood or charcoal generators and another 110 engines of 100-150 h.p. are to be equipped with coal generators in the future (Stockholm Cable, September 25, 1943). Tentatively it is suggested that the quantity of liquid fuels replaced by substitute fuels in railways during 1943 be put at about 15 percent of prewar consumption.

Shipping

The conversion of oil-using engines used in water transportation to solid fuels was hampered in France, as in all other countries, by technical difficulties. According to a decree of March 1942, the government offered to pay 75 percent of the conversion costs and to grant a loan repayable within 3 years for the remaining 25 percent. (Press, September 1942). By September 1942 only 25 ships had actually been converted. It was planned to increase the number of generator

driven ships to 60 by the end of 1942 and to at least 200 by the middle of 1943 (Press, December 1942). As only 400 of the available 2,000 motor barges were suitable for conversion (Deutsche Allgemeine Zeitung, May 21, 1943), the completion of this program would have meant the conversion of 50 percent of all suitable barges. It is improbable, however, that more than 100 ships were converted by July 1943. Towards the end of October 1943 it was stated that 150 ships had been or would shortly be converted to solid substitute fuels (Bern Cable, October 31, 1943). It is also reported that a few fishing boats and a small number of coastal vessels have been converted.

Agriculture

Relatively small progress had been made with the conversion of tractors. In the middle of 1943 it was stated that 15,000 tractors would be converted to the use of solid fuels in the near future (Oel und Kohle, May 1, 1943). In July 1943 it was decreed that all tractors would have to be converted as fast as possible. Licenses would be granted by the Agricultural Offices of the various Departments (Oel und Kohle, August 1, 1943, and October 1, 1943). Obviously, not much progress could possibly have been made before the 1943 harvest had been brought in. The only figures available on the number of converted tractors refer to ~~the~~ Normandy where towards the middle of the year 25-30 percent of the tractors were generator driven (British Enemy Oil Intelligence Committee, June 26, 1943). For the whole of France the percentage was probably below 10 percent.

Industry

No intelligence is available on the use of substitute fuels in industrial motors. Tentatively it has been assumed that 10 percent

of the 1938 requirements of liquid fuels have been replaced by substitutes. As the French motor manufacturing industry is working to an increasing extent for German account certain quantities of substitutes were used for engine testing, etc.

IX. THE USE OF SUBSTITUTE FUELS IN BELGIUM DURING 1943

Road Transportation

Official statistics on the number of motor vehicles in use in Belgium have been published in the Belgian Press. The increase in the number of substitute using vehicles and the decline in those driven by liquid fuel between September 1942 and February 1943 is shown in the following table:

BELGIAN MOTOR VEHICLES IN OPERATION

(By kinds of fuel used)

	February 1943	September 1942
Gasoline	13,777	21,351
Diesel Oil	2,332	2,674
Compressed Gas	9,572	7,377
Wood	3,423	2,806
Charcoal	69	114
Anthracite	6,603	5,521
Electric Cars	16	109
Creosote	7	9
Ammonia	12	6
Other fuels	109	21
TOTAL	35,911	39,988

The total number of substitute driven vehicles early in 1943 amounted to nearly 20,000 units as compared with 16,000 in September 1942. For several reasons progress during 1943 has most likely been small. The number of convertible vehicles was limited. The available

workshops (400 in 1942) were primarily working to equip German army trucks with generators. The quantities of fuel available were not sufficient to cover the requirements of vehicles already converted. In the spring of 1943 it was actually reported that all new generators were reserved for the German army. By June 1943 the total number of generator vehicles of all kinds, including 2,000 tractors, probably amounted to less than 22,000. In the autumn of 1943 it was decreed that private cars and small trucks should be equipped with coal-gas generators and that vehicles with over 12 h.p. would receive no more petrol.

Supplies of generator fuels have been strictly rationed. Though no information on the size of such rations is available, it may be expected that the utilization of generator vehicles has been considerably below that of liquid fuel driven cars in prewar times. Lubricating oil allowances amount to about 1 liter of lubricants per 40-50 km. travelled.

In the middle of 1942 there were some 12,000 substitute fueled vehicles in Belgium, accounting for some 30 percent of the road haulage and saving about 25,000 tons of light motor fuel and Diesel oil a year. In 1943 the number of substitute vehicles was 60 percent higher. The quantity of liquid fuel replaced by substitutes in road transportation during 1943 has been increased by the same percentage to 40,000 tons.

Railways

An increasing number of rail cars have been converted to substitute fuels. By the beginning of 1942, 103 out of 164 rail cars were equipped with generator motors and travelled 8,900 km. daily. No more recent data are available but it is reasonable to assume that all rail

cars suitable for conversion were converted by July 1943. The total has tentatively been put at 125. Probably only a few oil driven rail cars are still in use.

Inland Shipping

About 6,500 Belgian inland waterway vessels were registered with the Centrale Belge de Navigation Interieure which controlled inland shipping, including transport to Holland and Germany. This included about 900 motor vessels of an average size of 260 to 270 tons d.w.t. and some 250 diesel tugs. Early in 1942 it was planned to convert 1,000 motor ships and tugs, or practically all available motor shipping, to the use of substitute fuels. By June 1942 only 3 ships had been converted and early in 1943 it was reported that only a small number of barges were actually using substitute fuels. A decree issued by the German Military Commander in Belgium on June 24, 1943 prescribed that Belgian ships and small vessels must install generator engines forthwith. If the owners would not make the alteration voluntarily the work was to be carried out by the authorities at the expense of the owner. Subsidies covering the whole cost of conversion may be granted (Luxemburger Wort, August 24, 1943). Press notices of August, 1943 indicated that large scale conversion of shipping in Belgium had not yet started (Deutsche Zeitung in Norwegen, August 21, 1943). During the whole of 1943 probably less than 10 percent of the fuel requirements for inland and coastal shipping were replaced by substitute fuels.

Agriculture

The number of tractors converted to substitute fuels increased from 1,000 (out of a total of 3,500) in June 1942 to about 1,800 early in 1943.

X. THE USE OF SUBSTITUTE FUELS IN HOLLAND DURING 1943

Road Transportation

The number of substitute driven vehicles in use in Holland as of March 1943 was reported in the press as 15,000 or about double the number of converted vehicles in use in the autumn of 1941. Anthracite was used by 10,000 of these vehicles and peat by nearly 4,000. Only a relatively small number of trucks were using wood. Buses and taxis were frequently converted to the use of city gas (British Enemy Oil Intelligence Committee, August 9, 1943). Some methane gas was produced; the supplies were controlled by the State Office for Mineral Oil Products (Nederlandsche Staatscourant, August 25, 1942).

By the middle of 1943 the number of substitute using vehicles had probably increased to 18,000. Since that time new restrictions ~~had~~ have been imposed on the use of liquid fuels. In August 1943 the petrol rations for vehicles employed in food distribution were withdrawn. In September it was decreed that all small trucks and private cars had to be converted to substitute fuels, mainly peat (Deutsche Bergwerks Zeitung, October 8, 1943). About 87 percent of the total number of large private cars had already been converted, but 6000 small private cars were immobilized because of lack of liquid fuel (Deutsche Bergwerks Zeitung, November 17, 1943). With most of the liquid fuel using vehicles immobilized, substitute fueled vehicles will probably account for three-quarters of total 1943 road transportation.

Railways

No intelligence is available on the conversion of rail cars to the use of substitute fuels, but obviously some conversion must have

taken place. It has tentatively been estimated that 20 percent of the prewar petroleum requirements of the Dutch railways were replaced by substitutes in 1943.

Inland Shipping

One of the most important liquid fuel consumers was inland shipping. Before the war 11,000 engines with 250,000 h.p. (excluding motor tugs) were installed on inland barges. (Oel und Kohle, December 15, 1942). In June 1942 it was reported that 300 motor ships had been converted. Early in 1943 it was stated that a large number of Dutch barges were operating on producer gas and that the shortage of diesel oil could thus partly be overcome. Other reports indicate, however, that motor barges were frequently drawn by steam tugs and that only a few vessels had been converted to the "diesel cum gas" system. In November, 1943, it was stated that ships were being converted on a large scale. Probably not more than one-quarter of the 1943 fuel requirements for inland shipping will be satisfied by substitutes.

Some fishing and coastal vessels have also been converted to generator fuel, but the progress up to the middle of 1943 was not impressive. In this connection it is interesting to note that in the middle of 1943 the German Commissar for Holland requested the owners of sea-going vessels to furnish him with details necessary to enable him to obtain gas-generators. Vessels with engines of less than 50 or more than 1,000 h.p. were excepted. (MEW, Intelligence Summary, No. 6, August 28, 1943).

Agriculture

Early in 1943 farmers were warned that no allotment of liquid fuel for the threshing of the next crop could be distributed and that

either electric power or producer gas engines would have to be used for this purpose (British Enemy Oil Intelligence Committee, September 6, 1943). Some 1,500 tractors out of a total of 3,000 had already been converted to substitute fuel. Because of the lower utilization of substitute fuelled tractors, it is tentatively estimated that one-quarter of the 1938 agricultural liquid fuel requirements have been replaced by substitute fuels in 1943.

XI. THE USE OF SUBSTITUTE FUELS IN DENMARK DURING 1943

Road Transportation

The last detailed statistics available for the number of vehicles registered in Denmark refer to September 1942, and are as follows:

MOTOR VEHICLES IN USE IN DENMARK

	September 1942
Motorcycles	161
Private cars	3,800
Taxis	3,700
Buses	700
Trucks	22,700
TOTAL	31,061

Though the overall figures scarcely changed between September 1941 and September 1942 (from 30,410 to 31,061), the number of substitute using vehicles increased from a very small figure in 1941 to about 18,000 in September 1942, or more than half the total number of vehicles in use (Press, July 1943). In detail, there were 16,480 substitute fuelled trucks (15,750 generator trucks, 250 trucks using gaseous fuels, 170 using carbide, 120 using electricity and 190 using other fuels), 450 buses, 550 taxis and about 420 private cars. Since that time, however, the number of substitute using vehicles, especially trucks, has increased only slightly. By February 1943 there were 17,000 substitute fuelled trucks, ~~3,000~~ 2,200 private cars and 1,000 agricultural tractors (Stockholm Cable, March 18, 1943). Between February and July 1943 the number of converted vehicles probably increased as nearly all liquid fuel rations were cancelled. All trucks and taxis had to be converted to solid fuels and even fire services had to convert all trucks except

those used for active fire fighting. It was announced that 2,500 of the remaining trucks would be suitable for conversion. By June 1943 probably ~~1,500~~ 500 of these trucks and another 500 private cars, ambulances, and buses had actually been convertad, bringing the total number of conversions up to about ~~22-23,000.~~ 21-22,000

The newly installed generators burn l.t.c. coke. Licenses to install wood gemorntors were not issued aswood supplies fell far short of requirements (Nationaltidende, Oct. 18, 1943). Substitute fuel rations which could just be maintained during the first few months of 1943 had to be reduced in summer, first by 10 percent and then again by 25 percent; charcoal supplies were supplemented with peat. The coke needed for generators in 1943 was imported from Germany (Stockholm Cable, August 14, 1943); it was stated that supplies of coke were sufficient. In the autumn of 1943, however, Germany requisitioned Danish generator fuel and demanded regular monthly supplies for the army (British Enemy Oil Intelligence Committee, October 11, 1943).

Railways

Some diesel rail cars were converted to generators and used l.t.c. coke as fuel (Oel und Kohle, July 1943); the number is probably very small. The savings of liquid fuel in 1943 will probably not exceed 10 percent of peace-time requirements.

Shipping

In the course of 1942 some progress had been made in equipping inland motor berges, coastal fishing boats and tugs with coal gas generators of an improved type (Press, March 1943). Some fishing boats stationed at Frederickshaven were driven by natural gas and peat tar (Press, August 1942, and Petroleum Times, June 12, 1943). One ocean-going ship

of 3,000 tons dwt. was actually equipped with a coal gas generator (Berliner Boersen Zeitung, February 28, 1943). On the whole, fishing, coastal, and ocean vessels still depend on liquid fuel and the use of solid substitutes is very small.

Industry

The use of motor fuels in industry has been reduced very severely. Wherever possible, diesel engines have been converted to solid and gaseous fuels. Diesel electric engines of 330 h.p. have been successfully converted (Berliner Boersen Zeitung, April 2, 1943).

Quantities of liquid fuel saved by the use of substitutes

The total quantities of liquid fuel saved by the use of solid and gaseous substitutes may roughly be estimated at 50,000 tons. This estimate is based on the quantities of substitute fuels which were available. According to Berlingske Tidende, November 27, 1942, 500-600,000 cubic meters of generator wood were available as compared with requirements of 850,000 cubic meters. Total wood production for the year 1943/44 has been put at 2,040,000 cubic meters (Deutsche Bergwerks Zeitung, October 19, 1943). Natural gas accounted for the replacement of about 1,500 tons of liquid fuel and sewer gas for another 300 tons. The use of 10,000 tons of peat, coke and l.t.c. coke allowed some further savings of liquid fuel.

There is no doubt that the solid fuel position of Denmark, especially in the case of wood, is becoming increasingly strained. Rations can only be maintained at their present level as long as large quantities of solid fuels can be imported. The utilization of substitute fuel using vehicles will in the meantime be well below the rate of activity of liquid fuel using vehicles in prewar years.

XII. THE USE OF SUBSTITUTE FUELS IN NORWAY DURING 1943

Road Transportation

Early in 1943 it was reported in the German technical press that in January 17,600 motor vehicles were operating on substitute fuels and that 2,000 more cars were in the process of being converted. About 11,000 vehicles were using charcoal; most of the remaining vehicles were using wood, while a small number used carbide and other substitutes such as peat.

By July 1943 the total number of road vehicles using substitute fuels had probably reached 20,000. No information on the number of private cars, buses, and trucks is available. It has been tentatively estimated that 16,000 were trucks. The number of converted private cars was obviously very small; not until October 1943 was it stated that suitable small generators had been developed and that a large conversion of private cars and small trucks would take place during the winter months (Bern Cable, October 13, 1943).

In spite of the country's large wood resources, supply and distribution bottlenecks made necessary the introduction of substitute fuel rationing.

Rations are shown in the table on the following page.

In the autumn of 1943 it was reported that sufficient supplies of generator fuel would be available to cover essential requirements (Oel und Kohle, September 15, 1943).

MONTHLY RATIONS OF SUBSTITUTE FUELS IN NORWAY

(As of December 1942)

	Generator wood (in hectoliters)	Charcoal (in kilograms)
Trucks up to 1 ton	15	150
Trucks between 1 and 2.5 tons	40	400
Trucks over 2.5 tons	50	500
Buses	25-60	250-600
Private cars	10	100
Taxis	25	250
Agricultural tractors, stationary engines, etc.	no fixed rations.	

Shipping

Great efforts were made to convert the fishing and coastal shipping fleet to the use of substitute fuels. However, the generator model introduced in 1942 for use in ships proved to be a failure. Early in 1943 one hundred generators of an improved model were ordered (Hamburger Fremdenblatt, April 15, 1943). Difficulties were also ~~encumbered~~ encountered in providing a suitable charcoal for ship generators (Deutsche Bergwerks Zeitung, Sept. 14, 1943). The State offered to pay the total cost of conversion for large fishing boats and 50 percent of the cost for small boats. Reduced prices were to be charged for fuel supplied to fishermen and generator filling stations were to be established all along the coast.

In January 1943 it was reported that 70 small type fishing vessels were operating satisfactorily on wood gas generators and that it was planned to convert another 830 vessels. In June 1943 it was reported that 500 small gas generators were on order for boats chiefly along the

Skagerrak coast and that 456 fishing ships were then driven by generators. It was hoped that the number would be raised to 1,000 (Oel und Kohle, October 1, 1943). Some of the converted boats used solid fuels on the outward trip and motor fuel on the return journey.

Agriculture

Only a small number of tractors has been converted to substitute fuels; late in 1942 the number was only 125 out of a total of 4,500. The government actually bought 1,500 generators which were to be installed during the winter of 1942/43. In the spring of 1943 it was stated that by May probably 800-1,000 tractors would be using solid fuels (Fritt Volk, March 13, 1943). The number of generator tractors by the middle of 1943 probably did not exceed 1,200. The farmers were expected to supply their own generator fuel requirements.

Industry

No information is available on the number of generators used in industry. Early in 1943 it was stated that the distribution of diesel oil, fuel oil, and other oils for industrial uses would be suspended as of April 1943 and that industrial motors would have to be converted to electricity or to coal, coke, wood, or gas generators. In cases where such conversions were not possible the owners would have to file a form stating the reasons for the continued necessity of using liquid fuels. It has been assumed that 5 percent of the prewar industrial motor fuel requirements were replaced by substitute fuels in 1943.

Section C

THE USE OF SUBSTITUTE FUELS IN THE OCCUPIED COUNTRIES OF EASTERN AND SOUTHERN EUROPE, 1943

CONFIDENTIAL

XIII. THE USE OF SUBSTITUTE FUELS IN THE BALTIC STATES DURING 1943

Road Transportation

In 1942 it was decreed that all motor vehicles and agricultural tractors in Estonia, Lithuania and Latvia had to be converted to the use of wood generators. (Petroleum Press Service, December 1942). Intelligence on the progress of conversion is available for Estonia (Nachrichten fuer den Aussenhandel, November 26, 1942, and Stockholm Cable, July 1943).

NUMBER OF SUBSTITUTE-USING VEHICLES IN ESTONIA

	Summer, 1943	Autumn, 1942	
		Already converted	To be converted
Private cars	38	...	...
Busses	32	22	24
Trucks	700	555	300
Road tractors	30	764	270
Agricultural tractors	922		
TOTAL	1,722	1,341	594

As of the summer of 1943 it has been stated that 83 percent of all vehicles in use in Estonia have actually been converted. The generators used have mainly been imported from Sweden and Finland (British Enemy Oil Intelligence Committee, March 22, 1943). In the autumn of 1943 it was reported that the conversion of all motor vehicles used for civilian purposes, including agricultural tractors, had been completed. Late in 1942 it was planned to convert some 3,000 stationary engines to solid fuels (Nachrichten fuer den Aussenhandel, December 4, 1942).

No data are available on the progress of conversion in Latvia and Lithuania. It has been assumed that the experience in these two countries has been about the same as in Estonia.

The utilization of converted vehicles is probably less intensive than it was in 1938. The production of fire wood has not increased greatly because of labor and transportation difficulties. Increasing quantities of peat have, however, been used in Latvia. A rate of 50 - 60 percent of pre-war utilization has been assumed for the three Baltic countries. This would mean a saving of ~~nearly~~ about 7,000 tons of liquid fuel.

XIV. THE USE OF SUBSTITUTE FUELS IN THE GENERAL GOVERNMENT OF POLAND DURING 1943

Road Transportation

In general, regulations on the conversion of liquid fuel using motors to the use of substitute fuels in the General Government have been similar to those in Germany (see Krakauer Zeitung, July 14, 1943). Poland's domestic oil production, though sufficient to cover the country's peace-time requirements, has for the most part been exported to the Russian front or to Germany. The civilian economy has had to depend largely on substitute fuels. Because local resources of natural gas and wood are ample, Poland's substitute fuel position compares favorably with that of most other European countries.

In the autumn of 1942 far-reaching powers to regulate all phases of the road transport industry were given to the Department of Domestic Affairs in the General Government (Krakauer Zeitung, October 18, 1942). The supervision of the conversion of road vehicles to substitute fuels was delegated to the Department of Road Traffic. It immediately ordered the conversion of all trucks of $1\frac{1}{2}$ tons and over and the establishment of a network of generator driven truck services in Galicia. At three examining posts (Cracow, Warsaw, and Lwow) the suitability of all vehicles for conversion was determined. All new vehicles imported from Germany also used substitute fuels (Krakauer Zeitung, October 6 and 28, 1942).

Available fuels consisted mainly of wood, peat, coke, natural gas, and city gas. The forestry department held a sales' monopoly and

established a network of generator wood filling stations under the direction of the Department of Road Traffic (Krakauer Zeitung, July 14, 1942). By early 1942, 19 filling stations had been erected (Oel und Kohle, April 1, 1942). As of May 1942 the number of filling stations was reported to be 100 (Oel und Kohle, May 1942). Since then the number has increased; but many of these stations have been needed for fuelling German military vehicles.

In the autumn of 1942 it was stated that natural and other gas was being compressed and used as high pressure gas in motor vehicles. The Polish oil monopoly was put in charge of production and sales (Sued-Ost Echo, October 3, 1942 and Bern Cable, October 26, 1942). The construction of some 25 high pressure gas filling stations was planned, which would be sufficient to service about 4,000 commercial vehicles (Oel und Kohle, March 1943). However, it is unlikely that this program has actually been fulfilled.

Early in 1943 it was also reported that a new peat utilization company had been formed and that new methods for the extraction and preparation of peat for use in generator vehicles had been developed (Ostdeutscher Beobachter, March 16, 1943).

Because of the larger domestic supplies of substitute fuels, it has been assumed that in percentage terms about two to three times as many vehicles had been converted by July 1943 as in Germany.

Railways and Agriculture

Occasional reports (e.g., Krakauer Zeitung, September 5, 1943)

indicate that some locomotives have been converted to solid substitutes. Large quantities of substitute fuels are also consumed by agricultural tractors. Spring sowing was actually made possible by the use of such machines (British Enemy Oil Intelligence Committee, June 7, 1943). Including 1,000 tractors supplied by Germany, the total number of tractors in use in Poland has tentatively been estimated at 80 percent of the pre-war figure. Probably one-third of them use substitute fuels.

XV. THE USE OF SUBSTITUTE FUELS IN OCCUPIED RUSSIA DURING 1943

Road Transportation

Towards the middle of 1943 the German Commissioner for the Ukraine ordered the conversion of all liquid fuelled engines to producer gas. Motor vehicles in the Western Ukraine, approximately up to the line Kiev-Uman, had to be converted to wood and those in the Eastern Ukraine to anthracite, methane gas, etc. Only vehicles used by fire services, the ARP, and the army were exempt from this order (Verordnungsblatt des Reichskommissars fuer die Ukraine, July 20, 1943).

There is no information available on the total number of motor vehicles in Occupied Russia. It is known, however, that scarcely any trucks were left behind by the Russians and that whatever trucks were needed had to be imported from Germany (Deutsche Allgemeine Zeitung, January 2, 1943). In the 1942 OSS report, Civilian Consumption of Petroleum and Substitute Fuels in Axis Europe, it was assumed that some 30,000 trucks and a few thousand busses and private cars were used in that vast area. In the meantime more than one-half of Occupied Russia has been reconquered by the Russians. It may tentatively be estimated that the number of civilian trucks has been reduced to 20,000 of which perhaps 10,000 were generator driven. The conversion of all remaining liquid fuelled vehicles to the use of substitute fuels was ordered in the autumn of 1943 (Petroleum Press Service, October 1943, p 137).

Agriculture

Before the decree mentioned above was issued strenuous efforts had already been made to convert tractors to the use of substitute fuels (British Enemy Oil Intelligence Committee, June 26, 1943). Progress in

this program can, however, only be made at the expense of delaying the conversion program somewhere else in Axis Europe. Early in 1942, the Reich planned to supply 20,000 generator tractors to the Ostland (Oel und Kohle, April 1, 1942). In April 1942 the figure was raised to 26,000, including 5,000 which were supposed to be in use -- mainly in North and Central Russia where wood is available (Oel und Kohle, August 5, 1942). The import program was most likely not fulfilled. However, a considerable number of damaged Russian tractors were repaired during the winter of 1942 and converted to generator fuel (Deutsche Allgemeine Zeitung, March 24, 1943). The total number of tractors available in Occupied Russia early in 1943 was given in the German Press as 35-40,000. It has been assumed that most of these, probably 30,000, were either stationed in or withdrawn to the areas still under Nazi control; some 10-15,000 of them probably used solid fuels.

In the Ukraine, which is deficient in wood and coal, new light briquettes of straw, sawdust, and similar materials have been developed for use in generator tractors (Deutsche Bergwerks Zeitung, October 2, 1943). Natural gas is also used (British Enemy Oil Intelligence Committee, June 26, 1943).

Inland Shipping

It has been reported that inland water barges, especially on the Dnieper, have been converted to the use of solid fuels.

Savings of liquid fuel by the use of substitutes.

The total savings of liquid fuel in 1943 achieved by the use of gaseous and solid substitutes will probably amount to not more than 80,000 tons.

XVI. THE USE OF SUBSTITUTE FUELS IN SERBIA AND CROATIA DURING 1943

SERBIA

Road Transportation

In October 1942 a Central Office for Generators was established in the Office of the German Commissary for Economics (Oel und Kohle, November 1, 1942). This office organized and supervised the installation of generators in trucks, buses, tractors, rail cars, stationary engines, etc., and was also in charge of supply of generator fuels (Nachrichten fuer den Aussenhandel, November 3, 1942). German firms were asked to supply the necessary equipment for the conversion and for the production of charcoal from wood (Berliner Boersen Zeitung, February 12, 1943). Equipment could be imported duty-free.

With the huge conversion program under way in Germany, obviously only small quantities of generators and other equipment could be spared for Serbia. Conversions required a special permit for the local Traffic Commissioners. Sales of generator fuels were rationed. For the year 1943 it is tentatively estimated that 15 percent of the pre-war motor fuel requirements of the country have been replaced by substitute fuels.

CROATIA

Road Transportation and Industry

A special Office for Domestic Fuels was created in Croatia in September 1942 (Oel und Kohle, September 22, 1942). In view of the natural gas production of the country some stress was laid on the replacement of liquid fuels by gaseous fuel. The utilization of the country's natural gas resources was, however, limited by distribution difficulties, lack of steel bottles, etc. The use of the available timber resources was handicapped by transportation difficulties and labor shortages. By July 1943 probably only a relatively small number of vehicles had been converted to substitute fuels.

Some small savings of liquid fuel were probably achieved in industry. Early in 1942 it was decreed that stationary motors using more than .2 tons of liquid fuel a month must be converted to gas or alcohol within 6 months.

XVII. THE USE OF SUBSTITUTE FUELS IN GREECE DURING 1943

Road Transportation

Intelligence on the number of substitute using road vehicles in Greece is very scanty. Generator vehicles were first mentioned in the Press in the summer of 1942 when all road transportation with the exception of generator vehicles was taken over by the government. Local resources of substitute fuels are very small. This may partly explain why petrol rations were allowed to the German Post-office, to other public utilities and to village buses until February 1943. However, at this date, all petrol rations were cancelled and submitted to a re-examination. It was decreed that all vehicles would have to be converted to the use of substitute fuels. A Commissioner for Conversion to Generator Fuels in the Southeast with his residence in Vienna had already been appointed (Neues Wiener Tagblatt, January 20, 1943). A generator gas conference was scheduled for November 1943 at Bratislava to foster the conversion to substitute fuels in Greece and other Southeastern European countries. German manufactured generators were made available in limited quantities. By July 1943 the total number of generator buses and trucks was still very small and probably did not exceed 10 percent of the country's peace-time number of vehicles.